ANNUAL AND LOCAL VARIATION OF THE VARIETAL RESISTANCE OF RICE TO THE BLAST DISEASE

A Criticism to the Stability of Varietal Resistance based upon the Field Experiments in Taiwan

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Stability of the varietal resistance to the disease in rice is an important problem for breeding and spreading of the resistant varieties, since in certain varieties or cases the inherent varietal resistance is influenced greatly not only by the environmental conditions but also by the appearance of the new pathogenic races of the parasite. As has been pointed out by the author (1950,a)based upon the studies on the mechanism of prevalence of the rice blast disease, the inherent resistance of rice is of great importance for preventing the prevalency of the diseases, especially that in the tropics where the parasite survive almost all the year round. Nevertheless, the experimental foundations on the stability of the varietal resistance, especially those extending over the different climatic localities, are too little to criticize this problem.

"The experiments on the variation of blast injury in the rice varieties" which were conducted simultaneously at the seven different localities in Taiwan during the five consecutive years from 1934 to 1938 offered us a good material for criticising such a problem. This series of experiments was intended with the aim of clarifying the annual and local variation of varietal resistance of rice to the blast disease, and carried out under the direction of T. MIYAKE, the former chief of the Phytopathological Department of Agricultural Research Institute of Taiwan, with good cooperations of the staffs in seven agricultural experiment stations which are scattered at the different climatic localities in Taiwan. However, it is a great pity for the agronomists that the resultant data of the experiments have been left unadjusted and not published up to the present. The present author, who took charge a part of this series of experiments, has carried out many calculations based upon a vast number of the experimental data gained in all the stations where the present experiments were undertaken, and read justed as such a short paper as reported here. Although one and a half decades has passed from that time when the experiments were undertaken, the data still offer us many informations and are useful for

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the pathologists and agronomists who are engaging in breeding and extention of the disease resistant rice and in research as well as control of the rice disease.

MATERIALS AND METHODS

The experiments are consisted of two series. The lst series was continued for three consecutive years from 1934 to 1938, and the 2nd was for two years of 1937 and 1938. These two series of experiments were different in the varieties employed and some of the methods of observations.

(1) Varieties employed

Eight varieties were emp'oyed in each series of experiments, among which two, *i, e.*, Taichung No. 65 and Kameno-o, were used throughout these two series as the control varieties. The remaining six, each of them was the representative supreme varieties at the time of those experiments, were used for the test varieties. They are as follows:

Control varieties-Taichung No. 65 (P), Kameno-o(J)

Test varieties- The lst series of experiment (1934-1936) Mitsui(J), Asahi(J), Aikoku(J), Tainun No. 18(P)*, Taichung Sp. No. 6(P), Chia I woan No. 2(P)**.

The 2nd series of experiment (1937-1938) Tainun No. 22(P), Taipei No.6(P)Hsin Chu Aikoku No. 1 (P), Tainun No. 114(P). N. 103(P)*** Kao Hsiun No. 10 (P)

(2) The places where the experiments were performed.

Provincial Agricultural Research Institute at Taipei and six prefectural agricultural experiment stations at Taipei, Hsin Chu, Taichung, Tainang, Kao Hsiung and Hwalien.

(3) Experimental plots-Every plot was duplicated, and the area used for 1 plot was 0.1 or 0.2 are according to the field conditions of the stations.

(4) Manuring-As shown by the following table, twice amount as much as the standard of N, P_2O_5 and K_2O was given with ammonium sulphate, calcium perphosphate and potassium sulphate, respectively, with an exception at Taichung where triple amount was supplied (kg. per ha.).

Elements given	**** TAIPEI	***** Taipei	Hsin Chu	Taichung	Tainang	Kao Hsiung	Hwalien
N	18.8	15.6	22.6	34.5	20.2	24.0	22.7
P_2O_5	15.0	16.0	17.7	32.7	19.7	14.0	14.5
K_2O	7.5	18.0	12.0	20.6	18.8	14.0	15.8

(J) and (P) represent the Japanese endemic varieties and 'Peruglai' varieties, respectively 'Peruglai' is the general terminology given to the varieties which were bred in Taiwan.

*'Tainun' means Provincial Agricultural Research Institute.

**'Woan' means serotinous or late.

***This was bred in Tainan Prefectural Agricultural Experiment Station.

****Provincial Agricultural Research Institute ***** Prefectural Agricultural Experiment Station of Taipei. The same abbreviations will be applied correspondingly to the following all tables.

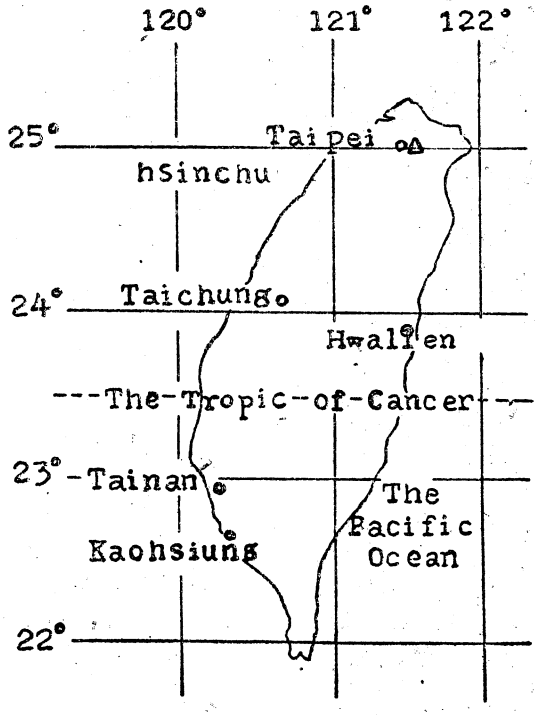

Fig. 1. A map showing the localities where the experiments were undertaken.

▲ Provincial Agricultural Research Institute

O Prefectural Agricultural Experiment Station

(5) Dates of sowing and transplanting. The dates of sowing and transplanting at each stations were somewhat different according to the weather conditions of the respective years, but such differences were in the extent shown in the following table.

Operation	TAIPEI	Taipei	Hsin Chu	Taichung	Tainang	Kao Hsing	Hwalien
Sowing	Big. Feb.	Big. Feb.	Big. Feb.	End. Jan.	End. Jan.	End. Den.	Big. Feb.
Transpl.	Mid. Mar.	Big. Mar.	Big. Mar.	End. Feb.	Mid. Eeb.	End. Jan.	Big. Mar.

(6) Density of transplanting (Number of hills per 0.1 a.).

TAIPEI	Taipei	Hsinchu	Taichung	Tainang	Kaohsiung	Hwalien
180	245	180	200	180	180	160

(7) Observations and examinations

Parts of pl. examin.	Observations	Growth stage examined
Leaves	P. L. (Percentage of infected leaves)* N. L. (Number of lesions per 1 leaf)* G. I. (Grade of infection estimatd by the scale)**	Culmination of tillering and the end of heading. respectively

Ears	P. E. (Percentage of infected ears)	Ten days after heading and mature stage
Nodes of culms	P. N. (Percentage of infected nodes)	Mature stage

*The observation was limitted to the 1st series of experiments.

**The observation was limitted to the 2nd series of experiments. The grade of infection was estimated by means of five scale, *i. e.*, none, slight, moderate, heavy and severe. which were prepared by the specimens of the affected plants.

RESULTS OF EXPERIMENTS

A. THE FIRST SERIES OF EXPERIMENTS IN 1934, 1935 AND 1936.

(a) Annual Variation of the Varietal Resistance

The annual variation of infection on the different parts of the rice plants are shown below in the average valus of infection at the seven different stations.

Table 1. Annual variations of the average value of the grade of infection at seven localities.

Observ. *	Year**	Kam.	Aik.	Mit.	Ash.	Tn. 18	Tc. S. 6	Tc. S. 65	Cl. 2
P. L. (Culm. of tillering)	1934	49.5	38.0	44.5	39.2	33.1	43.1	39.5	32.1
	1935	54.7	57.6	56.5	56.9	42.9	51.9	37.0	44.1
	1936	46.3	36.7	45.7	51.7	35.8	42.5	37.2	36.5
	Aver.	50.2	44.1	48.9	49.3	37.3	45.8	37.9	37.6
N. L. (Culm. of tillering)	1934	4.6	2.6	3.0	2.8	2.6	3.3	2.6	2.8
	1935	7.3	5.2	5.8	4.3	4.6	4.6	5.5	4.2
	1936	4.6	4.1	5.4	4.8	2.6	3.4	3.3	2.3
	Aver.	5.5	4.0	4.7	4.0	3.5	3.8	3.8	3.1
P. L. (End of heading)	1934	65.6	62.5	73.0	71.6	66.9	79.0	62.4	57.2
	1935	79.3	77.1	76.7	78.8	75.8	78.6	64.5	71.2
	1936	68.7	44.6	56.8	61.5	51.8	57.7	51.1	51.3
	Aver.	71.2	61.4	68.8	70.6	64.8	71.8	59.3	57.7
N. L. (End of heading)	1934	16.7	7.8	8.8	9.3	5.5	8.9	5.4	5.5
	1935	7.7	8.5	6.4	7.2	7.2	5.9	4.8	5.7
	1936	4.7	3.3	3.7	3.6	3.9	4.9	3.4	3.7
	Aver.	9.7	6.5	6.3	6.7	5.5	6.6	4.5	5.0
P. E. (Mature stage)	1934	46.5	49.6	38.7	43.8	26.0	49.0	18.3	27.5
	1935	67.4	62.9	44.2	55.6	32.0	49.3	27.0	36.3
	1936	49.4	41.9	35.8	35.1	22.4	38.4	19.8	26.3
	Aver.	54.4	51.5	39.5	44.9	26.8	45.6	21.7	30.0
P. N. (Mature stage)	1934	28.6	15.4	8.7	10.4	8.7	10.1	10.1	9.4
	1935	17.0	11.2	18.4	5.9	4.0	7.2	4.4	5.4
	1936	23.5	5.6	3.4	4.9	4.2	5.2	3.5	5.5
	Aver.	23.0	10.7	10.2	7.1	5.8	7.5	6.0	6.7

*The abbreviations 'P. L. '. 'N. L. ', etc. represent the observations stated in the experimental procedure (7).

**The abbreviations of variety name are as follows: Kam. Kameno-o, Aik. Aikoku, Mit.-Mitsui. Ash.-Asahi; Tn-.18-Tainun No.18, Tc. S.6- Taichung Sp. No.6, Tc. 65-Taichung No. 65,Cl 2-Chia 1 Woam No. 2. The same will be applied to the following all tables.

As shown in the above table, the disease was most prevalent in 1935, less in 1934 and least in 1936. The epidemic of the disease of leaves as well as ears (panicles) in 1935,

seemed to be due to the warm and moist weather, especially to cloudiness and rainfall at the biggining of March in the southern Taiwan, the early half of April in the middle, and the end of April in the northern, respectively, during which periods the disease of leavs was very prevalent. Notwithstanding such an annual variation of prevalence, the order of the grade of infection among the different varieties seems to be rather constant *inter se*. When these varieties are arranged according to the order number which represents the most resistant as 1 and the most susceptible as 8, the order of the resistance recorded by the different observations on the different parts of plants at the different growth stages will be tabulated as follows:

Table 2. Annual variations of the order of resistance determined by the average value of the grade of infection (Table 1) at seven localities.

Year	Observ.	Kam.	Aik*	Mit.	Ash.	Tn. 18	Tc. S. 6	TC.65	Cl.2
1934	P. L. (C. t.)*	8	3	7	4	2	6	5	1
	N. L. (C. t.)	8	1	6	4	1	7	1	4
	P. L. (E. h.)	4	3	7	6	5	8	2	1
	N. L. (E. h.)	8	4	5	7	2	6	1	2
	P. E. (M. s.)	6	8	4	5	2	7	1	3
	P. N. (M. s.)	8	7	1	6	1	4	4	3
	Aver.	8	4	5	6	1	7	2	2
1935	P. L. (C. t.)	5	8	6	7	2	4	1	3
	N. L. (C. t.)	8	5	7	2	3	3	6	1
	P. L. (E. h.)	8	5	4	7	3	6	1	2
	N. L. (E. h.)	7	8	4	5	5	3	1	2
	P. E. (M. s.)	8	7	4	6	2	5	1	3
	P. N. (M. s.)	7	6	8	4	1	5	2	3
	Aver.	8	7	6	5	3	4	1	2
1936	P. L. (C. t.)	7	3	6	8	1	5	4	2
	N. L. (C. t.)	6	5	8	7	2	4	3	1
	P. L. (E. h.)	8	1	5	7	4	6	2	3
	N. L. (E. h.)	7	1	4	3	6	8	2	4
	P. E. (M. s.)	8	7	5	4	2	6	1	3
	P. N. (M. s.)	8	7	1	4	3	5	2	6
	Aver	8	4	5	7	2	6	1	3

*As for the abbreviations, see experiment procedure (7).

From the average of the orders of resistance of different plant parts at different growth stages shown in the above table, the number of years which correspond to each average order in every variety is counted as the following table. (For instance, 'Aikoku' shows the 4th order in average resistance in two years, *i. e.*, 1934 and 1936, and the 7th in one year, 1935, accordingly this variety occupies the columns 4 and 7 with the numerals of 2 and 1, respectively.)

Table 3. Number of years corresponds to the average order of resistance.

Varieties	Order of resistance							
	1	2	3	4	5	6	7	8
Kameno-o								3
Aikoku				2			1	
Mitsui					2	1		
Asahi					1	1	1	
Tainan No. 18	1	1	1					
Taichung Sp. No. 6				1		1	1	
Taichung No. 65	2	1						
Chiai woan No. 2		2	1					

As shown in the above table, the annual variations of the varietal resistance are comparatively constant in spite of the difference of localities, and those eight varieties employed in this series of experiments are divided into the following three groups according to the order of resistance.

(1) The resistant group (The varieties which fluctuate from the 1st order to the 3rd in resistance)-Taichung No. 65, Tainun No. 18, Chia I woan No. 2,

(2) The intermediase group (The varieties which fluctuate from the 4th to the 5th) Mitsui, Aikoku, Asahi, Taichung Sp. No. 6.

(3) The susceptible group (The variety usually takes the last order) Kameno-o.

The annual variation of resistance is smallest in the resistant group, especially in Taichung No. 65 and Tainun No. 18.

(*b*) *Local Variation of the Varietal Resistance*

The three-years-average of the natural infection of the different varieties at the different localities is shown in the next table.

Table 4. Three-years-average of natural infection on the different parts of plants at the seven different localities

Locality	Observ.	Kam.	Aik.	Mit.	Ash.	Tn. 18	Tc.S. 6	Tc.65.	Cl. 2
TAIPEI	P. L. (C. t.)	22.4	21.1	33.6	34.9	20.1	32.2	21.6	20.1
	N. L. (C. t.)	1.9	2.0	2.1	1.9	2.1	2.3	2.0	1.9
	P. L. (E. h.)	62.9	42.9	49.4	56.1	35.6	54.7	41.7	44.3
	N. L. (E. h.)	3.0	4.2	2.2	2.6	1.9	3.1	2.1	3.1
	P. E. (M. s.)	15.2	19.7	7.3	5.6	4.4	13.2	3.6	5.0
	P. N. (M. s.)	14.1	3.7	0.8	2.3	1.0	2.4	1.5	0.9
Taipei	P. L. (C. t.)	69.1	54.0	63.9	63.0	48.9	59.6	64.3	43.5
	N. L. (C. t.)	7.1	4.0	7.0	7.2	3.1	4.3	8.0	2.5
	P. L. (E. h.)	89.3	87.6	90.0	92.6	79.1	88.5	91.3	87.9
	N. L. (E. h.)	10.9	13.1	10.6	9.7	8.8	6.3	7.8	9.0
	P. E. (M. s.)	88.0	87.9	48.2	58.3	19.7	67.4	32.4	22.0
	P. N. (M. s.)	49.0	21.9	8.2	0.7	9.8	14.7	13.1	8.3

Hsin chu	P. L. (C. t.)	72.4	41.1	57.8	56.0	49.3	57.9	43.9	53.3
	N. L. (C. t.)	6.1	3.1	5.1	4.6	3.9	5.0	3.9	4.9
	P. L. (E. h.)	77.1	55.7	69.4	72.1	64.9	70.1	54.3	73.1
	N. L. (E. h.)	4.4	3.3	3.6	3.8	2.6	3.5	2.3	2.6
	P. E. (M. s)	70.5	60.6	47.7	50.5	24.1	44.8	39.9	45.6
	P. N. (M. s.)	22.7	15.6	7.1	9.3	6.9	8.4	6.5	8.2
Taichung	P. L. (C. t.)	67.7	70.3	66.6	67.2	52.4	60.2	36.9	53.9
	N. L. (C. t.)	13.1	8.7	7.2	7.5	6.2	6.4	6.2	7.5
	P. L. (E. h.)	85.0	81.0	91.8	96.1	93.9	90.8	83.3	91.5
	N. L. (E. h.)	12.3	10.5	11.9	11.7	9.1	11.1	5.7	8.1
	P. E. (M. s.)	88.7	86.0	60.0	82.9	54.4	79.3	28.2	69.9
	P. N. (M. s.)	22.5	14.1	6.7	6.5	5.9	7.9	3.6	7.7
Tainang	P. L. (C .t.)	43.3	47.0	27.5	39.2	36.1	40.2	36.1	29.8
	N. L. (C. t.)	4.8	5.2	6.0	4.2	2.4	3.8	2.7	1.9
	P. L. (E. h.)	40.6	42.1	48.6	48.0	29.0	52.4	24.7	25.0
	N. L. (E. h.)	3.1	2.4	2.5	2.4	1.5	2.8	1.3	1.2
	P. E. (M. s.)	20.6	35.0	13.3	17.2	4.3	18.2	5.5	6.7
	P. N. (M. s.)	23.6	7.3	36.4	6.5	4.4	3.8	5.0	7.1
Kao hsiuu	P. L. (C. t.)	63.7	65.6	65.4	73.3	54.9	65.8	51.8	64.2
	N.L. (C. t.)	4.3	3.7	3.5	4.0	4.2	3.9	2.8	3.1
	P. L. (E. h.)	91.9	94.1	89.3	93.3	99.6	91.5	97.5	92.9
	N. L. (E. h.)	16.4	10.7	11.9	14.8	11.3	15.9	11.3	11.3
	P. E. (M. s.)	23.6	7.3	36.4	6.5	4.4	3.8	5.0	7.1
	P. N. (M. s.)	20.5	4.3	4.2	5.3	4.0	3.8	3.8	6.0
Hwalien	P. L. (C. t.)	12.8	13.0	18.1	10.5	8.1	4.9	4.7	5.3
	N. L. (C. t.)	1.1	1.0	1.1	0.9	1.0	0.8	1.0	0.8
	P. L. (E. h.)	33.3	35.6	43.4	34.9	30.7	34.4	24.4	12.7
	N. L. (E. h.)	1.6	2.0	1.5	1.5	1.4	1.3	1.3	1.2
	P. E. (M. s.)	3.6	8.1	5.9	8.6	3.5	6.2	14.9	3.6
	P. N. (M. s.)	8.5	8.3	8.5	8.1	5.8	8.9	8.4	8.3

Likewise the case of annual variation mentioned in the foregoing section, the numerals of the above-named datum are also represented by the order of varietal resistance (but the tables is abbreviated), and further the aveage of these order of resistance of each variety as each locality is calculated as the following table.

Table 5. Local variation of the average of the order of resistance of all the plant-parts of the different varieties

Locality	Kam.	Aik.	Mit.	Ash.	Tn. 18	Tc. S. 6	Tc. 65	Cl. 2
TAIPEI	7	6	4	5	1	8	3	2
Taipei	8	5	4	7	1	3	6	2
Hsin Chu	8	3	6	7	2	5	1	4
Taichung	8	6	5	7	2	4	1	3
Tainang	8	7	6	4	3	5	1	2
Kao Hsiun	7	3	3	8	5	6	1	2
Hwalien	6	7	8	5	2	3	4	1
Average	8	6	5	7	1	4	3	1

From the above table, number of localities correspond to the average order of resistance in each variety is tabulated as follows:

Table 6. Comparison of number of localities correspond to the average order of resistance of all the plant-parts in each variety

Variety	Order of resistance							
	1	2	3	4	5	6	7	8
Kameno-o						1	2	4
Aikoku			2		1	2	2	
Mitsui			1	2	1	2		1
Asahi				2	1		3	1
Tainang No. 18	2	3	1		1			
Taichung Sp. No. 6			2	1	2	1		1
Taichung No. 65	4		1	1		1		
Chia I waon No. 2	1	4	1	1				

As shown in the above table, the local variation of varietal resistance is considerably wider in comparison to the annual variation, though the employed varieties are roughly groupsed also into the following three categories.

(1) The resistant group (The varieties which fluctuate from the 1st order to the 4th in resistance) Tainun No. 18, Taichung No. 65, Chia I woan No. 2.

(2) The intermediate group (The varieties which fluctuate from the 3rd to the 8th.) Aikoku, Taichung Sp. No. 6, Mitsui, Asahi.

(3) The susceptible group (The variety which fluctuate from the 6th to the 8th.) Kameno-o.

In view of the results stated above, the variation of varietal resistance in the different years is smaller then that at the different localities, and the range of variations under different environmental conditions is smaller in the resistant varieties than in the susceptible ones.

B. THE SECOND SERIES OF EXPERIMENTS IN 1937 AND 1938.

(*a*) *Annual Variation of the Varietal Resistance*

The results of Observations of infection on the different plantparts of the varieties in each year are shown in an average of the records at the seven localities.

Table 7. Annual variations of the average value of the grade of infection at the seven localities

Observ.*	Year	Kam.**	Tn. 22	Tp. 6	H. A. 1	Tc. 65	Tc. 114	N 103	KH.10
G. I. (Culm. of tillering)	1937	2.9	3.3	1.7	1.9	2.3	1.0	1.7	1.1
	1938	1.9	1.7	1.4	1.0	1.4	0.4	1.1	1.2
	Aver.	2.4	2.4	1.5	1.4	1.9	0.7	1.4	1.1
G. I. (End of heading)	1937	3.0	2.8	1.5	1.7	1.7	0.8	1.8	1.2
	1938	2.0	2.1	1.4	1.1	1.6	0.8	1.9	1.6
	Aver.	2.3	2.3	1.4	1.3	1.5	0.7	1.7	1.3
P. E. (Ten days after heading)	1937	42.3	18.9	16.3	31.2	22.1	8.7	15.8	6.5
	1938	17.3	12.8	13.5	27.4	7.9	5.2	11 6	4.2
	Aver.	29.8	15.9	14.9	22.0	15.0	6.3	12.6	5.4

P. E. (Mature stage)	1937	65.2	60.1	43.4	54.7	26.5	27.9	37.4	20.6
	1938	49.0	38.2	41.5	45.7	27.2	26.7	39.8	29.7
	Aver.	57.1	49.2	42.5	47.7	26.8	26.8	38.6	24.9
P. N. (Mature stage)	1937	23.3	5.7	21.9	31.9	8.5	6.6	6.3	9.2
	1938	35.9	6.3	22.8	39.2	7.9	7.1	5.6	4.9
	Aver.	28.0	6.0	22.4	34.7	8.2	6.9	5.9	7.7

*G. I. means the grade of infection of leaves which was represented by the index number determined by presumption with the naked eye, i. e. no or a little-0, slight-1, moderate-2, heavy-3, severe-4.

**Abbreviations of the variety name. Tn. 22, -Tainun No. 22. Tn. 6-Taipei No. 6, H. A. 1-Hsinchu-Aikoku No. 1, Tc. 114-Taichung No. 114, K. H. 10-Kaohsiung NO. 10.

As shown in the above table, the disease was more prevalent in 1937 than in 1938 due to the susceptibility of rice plants predisposed by coolness during the middle of March and intense propagation of the blast fungus induced by rapid ascending of temperature during the middle of April, and in the northern Taiwan the ear blast was also prevalent due to the rainy weather during the early half of June.

Likewise the foregoing experiments, the annual variation of the order of varietal resistance will be tabulated as follows:

Table 8. Annual variations of the order of resistance determined by the average value of the grade of infection at the seven localities

Year	Kam.	Tn.22.	Tp. 6	H. A. 1	Tc. 65	Tc 114	N. 103	K. H. 10
1937	8	8	4	6	5	2	3	1
1938	8	5	5	7	3	1	4	2
Aver	8	7	5	6	4	1	3	2

From the above table, number of years corresponds to the average order of resistance in each variety will be induced as the following table.

Table 9. Number of years corresponds to the average order of resistance in the different varieties

Varieties	Order of resistance							
	1	2	3	4	5	6	7	8
Kaneno-o								2
Tainun No. 22			1		1	1		
Taipei No. 6				1	1			
Hsin Chu Aikoku No. 1						1	1	
Taichung No. 65			1		1			
Taichung No. 114	1	1						
N. 103			1	1				
Kao Hsiun No. 10	1	1						

As shown in the above table, the employed eight varieties can be divided into the following 4 classes according to the order of resistance.

(1) The resistant group (The varieties which fluctuate from the 1st order to the 3rd.)-Taichung No. 114, Kao Hsiun No. 10.

(2) The moderately resistant group (The varieties fluctuate from the 3rd to the 5th.)-N. 103, Taichung No. 65, Taipei No. 6.

(3) The moderately susceptible group (The varieties fluctuate from the 5th to the 7th.)-Tainun No. 22, Hsin Chu Aikoku No. 1.

(4) The susceptible group (The variety unsually takes the last order) Kameno-o.

(b) Local Variation of the Varietal Resistance

The two-years-average of the natural infection of the different plant-parts at the different localities is as undermentioned.

Table 10. Two-years-average of the natural infection on the different parts of plants at the seven different localities

Locality	Observ.*	Kam.	Tn.22	Tp. 6	H. A. 1	Tc. 65	Tc. 114	N. 103	K.H.10
TAIPEI	G. I. (C. t.)	2.0	2.0	1.5	1.5	2.0	0.5	1.5	1.5
	G. I. (E. h.)	1.5	2.0	1.0	1.5	1.5	1.0	2.0	1.5
	P. E. (A. h.)	0.0	0.0	0.1	0.2	0.9	0.0	0.0	0.0
	P. E. (M. s.)	51.7	31.8	19.3	29.0	8.4	4.2	12.4	10.5
	P. N. (M. s.)	24.4	3.5	31.0	48.5	6.4	6.1	3.6	5.5
Taipei	G. I. (C. t.)	2.5	2.5	1.5	2.0	2.5	1.0	1.5	1.0
	G. I. (E. h.)	2.5	2.0	1.0	1.5	1.5	1.0	1.5	1.0
	P. E. (A. h.)	52.7	17.8	17.6	46.8	20.2	6.4	7.6	3.2
	P.E. (M. s.)	91.0	92.2	65.9	76.7	37.7	46.4	59.3	31.8
	P. N. (M. s.)	52.8	4.2	46.1	57.9	13.4	10.3	4.7	8.5
Hsin Chu	G. I. (C. t.)	3.5	2.5	2.5	1.5	2.0	1.5	1.5	1.0
	G. I. (E. h.)	4.0	4.0	3.0	2.0	2.0	1.0	4.0	1.5
	P. E. (A. h.)	20.6	20.4	29.4	33.3	33.1	13.8	25.1	6.7
	P. E. (M. s.)	45.0	53.0	71.1	80.5	40.1	50.7	67.4	42.2
	P. N. (M. s.)	2.9	3.9	3.2	4.2	2.2	3.9	1.5	1.9
Taichung	G. I. (C. t.)	2.0	2.0	1.0	1.0	2.0	0.5	1.0	1.0
	G. I. (E. h.)	2.0	2.0	0.5	0.5	1.5	0.0	0.5	0.5
	P. E. (A. h.)	41.4	35.3	14.8	25.0	10.0	6.9	21.4	7.8
	P. E. (M. s.)	48.5	32.6	21.7	28.6	14.7	7.9	22.0	8.4
	P. N. (M. s.)	49.2	11.8	28.8	45.8	16.8	7.3	14.7	6.8
Tainang	G. I. (C. t.)	3.0	3.5	1.5	1.0	2.0	0.5	1.0	1.0
	G. I. (E. h.)	3.0	2.5	1.0	1.0	0.5	0.0	1.0	1.0
	P. E. (A. h.)	22.4	3.3	13.5	21.0	5.8	1.7	8.1	3.8
	P. E. (M. s.)	47.6	34.0	24.7	23.1	14.0	16.0	25.3	11.7
	P. E. (M. s.)	32.8	7.2	23.9	60.9	8.5	10.4	4.4	12.5
Kao Hsiun	G. I. (C. t.)	1.5	3.0	2.0	1.5	2.0	1.0	3.0	1.5
	G. I. (E. h.)	2.0	4.0	3.0	1.0	4.0	2.0	4.0	4.0
	P. E. (A. h.)	32.0	34.2	22.9	23.8	19.5	15.6	25.6	12.8
	P. E. (M. s.)	84.0	86.7	77.0	68.3	69.1	57.3	76.9	58.9
	P. N. (M. s.)	23.7	6.4	12.2	16.7	7.0	6.1	8.2	6.1
Hwalien	G. I. (C. t.)	2.0	2.0	0.5	1.5	0.5	0.5	0.5	1.0
	G. I. (E. h.)	2.0	1.5	1.5	2.0	1.5	1.0	1.0	1.5
	P. E. (A. h.)	7.8	0.2	0.2	4.2	1.1	0.0	0.3	0.2
	P. E. (M. s.)	22.0	13.9	17.8	27.5	3.0	5.2	7.1	11.1
	P. N. (M. s.)	11.4	5.3	11.7	9.2	3.4	4.2	4.5	12.5

*The abbreviation 'G. I.' and 'A. h.' mean 'grade of infection' and '10 days after heading', respectively.

When the variation of varietal resistance to leaf-blast infection tabulated above, *i. e.*, the data of the column of G. I. (Grade of infection), is compared by the number of

localities corresponds to each grade of infection at the different growth-stages, the data will be rearranged as follows:

Table 11. Number of localities corresponds to the grade of infection of leaves represented by the index number

Grade of infect.	Kam.		Tn. 22		Tp. 6		H. A. 1		Tc. 65		Tc. 114		N. 103		K. H. 10.	
	C. t.	A. h.	C. t.	A. h.	C. t.	A. h.	C. t.	A. h.	C. t.	A. h.	C. t.	A. h.	C. t.	A. h.	C. t.	A. h.
0												2		1		1
0.5					1	1		1	1	1	4		1	2		2
1.0					1	3	2	2			3	4	2	1	5	1
1.5	1	1		1	3	1	4	2		4			3	1	2	2
2.0	3	3	3	3	1		1	2	5	1		1				
2.5	1	1	2	1	1				1							
3.0	1	1	1			1										
3.5	1		1													
4.0		1		2												

From the above table, the employed varieties can be divided into the following 4 classes according to the resistance of leaves.

(1) The resistant group (The grade of infection usually lies o-1.0)-Taichung No. 114.

(2) The moderately resistant group (The grade of infection lies 0-1.5) Kao Hsiun No. 10, N 103.

(3) The moderately susceptible group (The grade of infection usually lies 0.5-2.5) Hsin Chu Aikoku No. 1, Taipei No. 6, Taichung No. 65.

(4) The susceptible group (The grade of infection lies 1.0-4.0)Kameno-o, Tainung No. 22.

In the next place, the local variation of the average order of resistance as regard the ear-blast and node-blast will be tabulated in an average of 2 years.

Table 12. Local variation of theaverage order of resistance of ears and nodes of culms

Locality	Kam.	Tn. 22	Tp. 6	H. A. 1	Tc. 65	Tc. 114	N. 103	K. H. 10
TAIPEI	8	4	6	7	4	1	2	2
Taipei	8	5	6	7	4	2	2	1
Hsin Chu	1	6	7	8	5	3	3	2
Taichung	8	6	4	7	3	1	4	2
Tainang	8	4	6	7	3	1	5	2
Kao Hsiun	8	7	5	4	3	1	5	1
Hwalien	8	4	6	7	2	1	3	5
Aver.	8	5	6	7	3	1	4	2

Inducing from the above table, number of localities corresponds to the average order of resistance of the ears as well as nodes of culms of each variety can be tabulated as follows:

Table 13. Comparison of number of localities corresponds to the average order of resistance of ears and nodes of culms

Variety	Order of resistance							
	1	2	3	4	5	6	7	8
Kameno-o	1							6
Tainang No. 22				3	1	2	1	
Taipei No. 6				1	1	4	1	
Hsin Chu Aikoku No.1					1		5	1
Taichuug No. 65		1	3	3				
Taichuug No. 114	5	1	1					
N 103		2	2	1	2			
Kao Hsiun No. 10	2	4			1			

From the above table, the employed eight varieties are divided into the following 4 groups according to their resistance of ears as well as nodes of culms.

(1) The resistant group (The varieties fluctuate from the 1st order to the 5th.)-Taichung No. 114, Kao Hsiun No. 10.

(2) The moderately resistant group (The varieties fluctuate from the 2nd to the 5th)-N 103, Taichung No. 65.

(3) The moderately susceptible group (The varieties fluctuate from the 4th to the 8th.)-Taipei No. 6, Tainung No. 22, Hsin Chu Aikoku No. 1.

(4) The susceptible group (The variety usually takes the last)-Kameno-o.

Judging from the above-mentioned grouping based upon the order of resistance of leaves, ears and nodes of culms, the employed varieties can be divided into the following four groups each of which being consisted with the varieties completely same as in the annual variation,

(1) The resistant group Taichung No. 114, Kaohsiun No. 10.

(2) The moderately resistant group N 103, Taichung No. 65, Taipei No. 6.

(3) The moderately susceptible group Hsin Chu Aikoku No. 1, Tainang No. 22.

(4) The susceptible group-Kameno-o.

DISCUSSION AND CONCLUSION

The present experiments on the variaties of variatal resistance were repeated in five different years at the seven different stations which are scattered in the different climatic regions in Taiwan extending from 25°02′ N (Taipei) to 22°37′ N (Kao Hsiun), though among which two, *i. e.*, Provincial Agricultural Research Institute and Taipei Prefectural Agricultural Expriment Station situate closely one another. Moreover, the cultural conditions of the experimental plots, *e. g.*, manuring density of transplanting, season of sowing and transplanting, *etc.*, were considerably different according to the difference of stations.

Further the varietal resistance was compared by the mutual average order of resistance calculated from the grade of infection at the different growth stages on the different parts of plants examined, *i. e.*, leaves, ears and nodes of culms. Even under such different experimental conditions, it is an important fact that the variation of varietal resistance was restricted to a rather limitted extent when considered as a whole. For example, in the first series of experiments which were continued three consecutive years, the annual variations of varietal resistance in the resistant varieties extended over three orders from the 1st to the 3rd in resistance, those of the intermediate group ranged from the 4th to the 7th, and the susceptible alway stook the last, the 8th. Also in the local variation at the seven different places, similar three groups consisted of the varieties completely same as in the annual variation could be distinguished, though the range of order of resistance of the respective variety was somewhat different from the annual variation. In the second series which was conducted in the two consecutive years, four groups could be divided also according to the grades of infection in both of the data calculated from the annual average and those from the local average, and moreover, the varieties which are included in each group were also same in both, except only one, Taipei No. 6 which was included in the last order of the class of moderately resistant in the annual variation, and in the first of the class of moderately suscenptible in the local variation. As a whole, the variation of order of resistance was somewhat larger when calculated by the local average than when by the annual average. It is not clear whether or not this is due to the fact that the local difference of climatic conditions at the different localites was larger than the annual difference at the same locality.

In the next place, Taichung No. 65, the resistaut control variety, was included in the resistant group and occupied the 1st rank of that group in the 1st series of experiments, while it was included in the group of moderately resistant and occupied the 2nd position in the second series. This is due to the difference of resistance of the varieties employed in these two series of experiments. Namely, the varieties employed in the second series of experiments are considerably resistant in comparison to those used in the 1st series due to the advancement of breeding on the disease resistance. On the other hand, Kameno-o, the susceptible control variety, was always ranked to the last order (most susceptible) throughout both series. It goes without saying, however, even such variety as Kameno-o, the data of the individual cases of observation on the different plant parts at the different growth stages, were not always completely parallel, but it ranked to the most susceptible order when the data under all the environments were avaeraged. Considering the results stated above, the varietal resistance of rice to the blast disease is considerably stable, so far as the present two series of experiments were concerned.

Nevertheless, the term 'stable' used in the present paper is merely a comparative one, and, as a matter of fact, it was rendered as 'considerably stable' when considered as a whole in such experiments of large as scale the present field trials. Accordingly, in such experiments conducted under the limitted experimental conditions as those made by the previous workers which will be mentioned later, or even in certain cases of the limitted extent of the present experiments, it may naturally be considered that there are

considerable variations of varietal resistance, In order to discuss this matter more decidedly. some considerations on the causes of variations of varietal resistance will be briefly stated below. though the following phenomens are more or less correlated *inter se*, and are not distinguished clearly each other.

In the farmers' paddy field, impurity of seeds, for example, mixing of different varieties or lines which resemble closely each other in the morphological characters often induce the adverse order of apparent varietal infection. On the other hand, conscious or unconscious artificial selection of the resistant lines among the definite variety will also result the phenomenon which is mistaken as the natural variation, induced by the environmental conditons. Further, under certain environmental conditions, especially when the plants are raised in the places quite different from the native localities in the weather conditions, natural segregation may offen induced and still in the limitted cases even natural hybridization may occnr. In the present experiments, however, the seeds used in these different stations were distributed from the Agricultural Research Institute after approval on the heritable uniformity. Therefore, the variation of the varietal infection occurred in those different stations can be considered not to be due the ununiformity of the seeds employed.

The reactions of rice to the natural-and artificial environments which induce susceptibility, *e.g.*, coolness, excess of nitrogen supply, *etc.*, are different according to the physiological characters of the respective variety, accordingly undgr such conditions the resistance or susceptibity of certain varieties is often extremely effected, and that of others is almost uneffected. Moreover, the growth habits of the respective variety induced by the response to temperature condition, length of daytime, *etc.*, also cause the variation of infection, since the susceptibility or resistance of rice plants to the blast infection is different according to the growth stage (age) of them (HASHIOKA, 1950,a), especially the necks of panicles are most susceptible at the time of heading, but become resistant with the lapse of days after heading. In this connection, IKATA *et al*, (1931) pointed out that many of the varieties in the northern Japan become susceptible to the neck-blast when they are introduced to the southern Japan. According to the presumption of the present author, this fact seems to be due to the promotion of heading in the northern varieties induced by the short day in Okayama (Southern Japan) where their experiment was conducted, or to the other response of them to the environmental factors different from those of Hokkaido and Tohoku districts, the native place of the northern varieties. YASUDA (1942) also reported an example in the middle of Japan that the order of neck-blast infection among several varieties employed was reversible when they were cultured either in the mountains or in the plains. This seems also due either to the short day or to the dewy and cooler condition of the mountains favourable for the blast prevalency. According to BOKURA (1934), the fact that the neck-blast resistance of certain varieties except highly resistant ones is somewhat variable when grown in different localities, is due to the difference of time of heading during which the plants are blasted, if temperature is favourable for the fungus. In this case, the rainy and warmer condition favourable for the infection for only a few days during heading effects greatly for the varietal infection,

accordingly the order of varietal infection may be easily reversible according to the weather conditions during such a short period. Such phenomena as mentioned above may be regarded either as the so-called disease escaping due to the difference in growth duration of each variety of as those due to the physiological change of resistance effected by the environmental conditions.

There is one more important cause of variation of varietal resistance concerned the part of the parasite. As early as 1922-23, SASAKI reported from Shikoku, Japan, that the heavy infection of the rice blast disease noticed on five plants out of 766 F_2 individuals which were derived from the crossing between Tsurugi No. 160 (resistant) and Benkei No. 116 (resistant) might be due to a race (race B) of *Piricularia oryzae* more virulent than the race (race A) against which the parental resistance was tested, since both parents were proved to be completely resistant to race A. This is the first report which paid attention to the variability of the varietal resistance to the blast disease. Since that time, there have been some advanced steps on the problem of variation of the varietal resistance. TOCHINAI *et al.* (1932), HEMMI *et al.* (1934; 1941) made studies on the physiologic specialization of the rice blast fungus, but they did not develop to the variation of varietal resistance occurring in nature, although they made also some laboratory experiments on the difference of pathogenicity of the strains of the fungus. More recently, in Japan, the problem of races of the blast fungus has become to be reconsidered according to the world advancement of such studies. In this connection, SUZUKI (1951) found recently eight different races of the blast classified accosding to the mode of germinatios of conidia as well as appsessoria formation, and made some laboratory inoculation experiments with certain differential varieties. These studies mentioned above made an advancement of the problem of the variation of varietal resisnce induced by the heritable characters of the blast fungns, but under the present status of study no experi-mental result has been reported on the appearance of the different races of the fungus which are fully influential for govering the variariation of natural infection and prevalency.

In Louisiana, RYKER (1947, 1948) reported that the resistance of the rice varieties to the leaf spot, *Cercospora oryzae*, was broken by the appearance of the new pathogenic races of the fungus, and the natural prevalency due to such new race occurred in the paddy field where those past resistant varieties were raised. In. the rice blast disease, however, such a distinct phenomenon has not yet been known experimentally up to the present, though some empirical obserations have seldom been reported. Also in the present experiments which are largest in scale among the field trials on the blast disease ever reported up to the present, presence of the races of the fungus distinctly different in pathogenticity had not been found.

The grade of resistance of varieties employed in the present studies, especially those used in the 1st series of experiments, was very low in comparison to that of the varieties distributed at present. Recently the blast resistance of the rice verieties widely distributed in Japan as will as Taiwan has been elevated greatly due to the advancement of breeding, especially the introduction of the resistant genes of the tropic varieties to the Japnanse varieties. As has been proved experimentalily by the present author (1950, b, c), in general,

high resistance of the 'indica' type varieties to the blast, especially the leaf-blast, is hardly effcted by the environmental conditions in spite of the fact that the susceptibility of the 'Japonica' type varieties is considerably influenced by the environmental factors, such as coolness, nitrogen manuring, *etc.* The varietal blast resistance of rice, therefore, is becoming more stable year by year.

中　文　摘　要

季節與區域對於稻熱病抗病性之變異

熱帶環境下所栽培之稻作品種，必須具有堅定之抗病性，方能抑制稻熱病之蔓延，但此種抗病性，是否因季節及稻作栽培區域不同，而影響其穩定情形；斯乃育種及推廣上，極關重要之問題，此亦本試驗所欲探討之目的。

根據五年來（二十三年～二十七年）在臺灣不同氣候區，包括25°02′N（臺北）至22°37′N（高雄）分別在七個場所，獲得之試驗結果，每年按稻作不同生育時期，對於葉、節及穗頸稻熱病之抗病程度，逐一加以分析其結果，在不同區域中，品種間抗病性之强弱，雖略有差異，惟大體言之，其差異之程度並不太大，但在不同季節及栽培情形之下，抗稻熱病之特性，恒有一定不變，惟種子之純度，植株之自然變異，品種之生理反應，以及病原菌之生理小種等現象，多少能够誘致抗病性發生變異，應加考慮。

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